Chapter 22 Contents

Chapter 22 Geotechnical Baseline Reports Produced for Design-Build Projects

22.1 Definition

A Geotechnical Baseline Report (GBR) is a document provided to bidders of design-build projects that summarizes the factual geotechnical data for a project and provides a framework or basis for interpretation of that data. The GBR should contain a collection of all the geotechnical data (e.g., boring logs, laboratory test data, geophysical data, field test results, geological field reconnaissance observations, rock slope mapping, etc.) available within the project limits. The geotechnical engineer or engineering geologist who develops the GBR should perform the geological interpretation necessary to accurately portray the subsurface conditions, and evaluate the geotechnical feasibility of the proposed design/construction project features. An important aspect of the GBR is an assessment of how the geotechnical conditions may affect the design and constructability of the project elements. This assessment is necessary so that potential bidders can better define risk during the bidding process.

22.2 Policy – Field Investigation Requirements for the GBR

The level of geotechnical field investigation necessary for preparation of the GBR shall be determined or approved by the State Geotechnical Engineer. The State Geotechnical Engineer and Region/Headquarters management will review and agree upon the short-term (i.e., during the contract) and long-term (i.e., after the contract is completed to the end of the design life of the facility) project performance risks when determining the initial level of investigation required and whenever field findings significantly alter those risks. The level of geotechnical investigation shall consider the amount of information necessary to reduce project bid costs. The amount of geotechnical investigation needed will be project specific, and shall be determined based on the guidelines provided herein.

The goals of the typical geotechnical investigation for design-build projects are to:

- Identify the distribution of soil and rock types within the project limits, and assess how the material properties will affect the design and construction of the project elements.
- Define the ground water and surface water regimes. Especially, the depth, and seasonal and spatial variability, of groundwater or surface water within the project limits. The locations of confined water bearing zones, artesian pressures, and seasonal or tidal variations should also be identified.
- Identify and characterize any geologic hazards that may be present within or adjacent to the project limits (e.g., landslides, rockfall, debris flows, liquefaction, soft ground or otherwise unstable soils, seismic hazards, etc.).
- Assess the feasibility of the proposed alignments, including the feasibility and conceptual evaluation of retaining walls and slope angles for cuts and fills.
- Assess the feasibility of infiltration or detention facilities that may be needed, as well as provide conceptual recommendations for pond slope angle and infiltration rates to enable the Design Builder to estimate the approximate size and number of those facilities required for the project.
- Identify potential usability of on-site materials as fill, and/or the usability of nearby materials sources.
- For structures including bridges and cut-and cover tunnels, large culverts, signs, signals, luminaires, walls, or similar structures, provide adequate subsurface information for the design-builder to estimate foundation types and costs.

- For projects that may include tunnels, trenchless technology, or ground improvement, provide adequate information to assess the feasibility of various construction methods and potential impacts to adjacent facilities.
- For projects that may include landslides, rockfall areas, and debris flows, provide adequate information to evaluate the feasibility of various stabilization or containment techniques.

To accomplish these goals, the typical geotechnical investigation should consist of the following:

- A review of historical records of previous investigations and construction of existing facilities.
- A geological site reconnaissance of the proposed alignment, focusing on all key project features, and identification of potential hazards within and adjacent to the alignment.
- A subsurface investigation consisting of an appropriate combination of borings, cone probes, field testing, field instrumentation (such as piezometers or inclinometers), and geophysical surveys.

In general, the field investigation should meet the requirements in **WSDOT GDM Chapters 2 and 3**, and any logs produced shall be consistent with the requirements in **WSDOT GDM Chapter 4**.

Note that a review of land use records or reports that describe previous site uses, especially those that could identify the potential for hazardous waste or the potential to encounter archeological artifacts, will specifically not be included in the GBR for WSDOT projects, but will be contained in a separate report produced by the Environmental Affairs Office and/or the region, or their consultant.

As a starting point, utilize existing subsurface information from records and augment that information with additional borings, cone probes and/or geophysical surveys to fill in gaps in the existing information. Borings or cone probes should be spaced as discussed below.

It should be recognized that at the time of the field exploration many of the features investigated may not be defined. The geotechnical designer developing the GBR will have to utilize professional judgment to assess what project elements may need to be investigated and where they will likely be located in order to perform an adequate field investigation.

Where specific structure or other project feature locations (including infiltration facilities) are known with certainty, the design-builder may have no option to relocate or resize the structure. In this case, the field investigation program for the GBR should be extended to include all borings needed to meet state and national standards for final geotechnical design of the structure(s) or other features, at the state's discretion.

For cuts and fills, test borings should be advanced every 500 to 1,000 ft along the project alignment where cuts or fills are anticipated. For large cuts or fills (e.g., 30 ft or more in height) an additional borings near the top of the proposed cut or toe of the proposed fill to evaluate cut/fill feasibility and overall stability may be necessary. Depths of the borings should be at least twice the vertical height of the fill and at least 10 ft below the base of the cut. If soft/poor soils are encountered, additional depth will be needed to define the subsurface conditions.

For bridges and cut-and-cover tunnels, borings should be completed at each abutment, or portal, and at least every 300 to 500 ft of structure length for longer bridges and cut-and-cover tunnels. Borings for structures should be a minimum of 50 feet in length unless rock or other very dense material is encountered. If rock is encountered, the rock should be cored for at least 10 feet. For structures founded on piles or shafts, a good rule of thumb is to obtain at least 30 feet of soil that has a standard penetration resistance of 30 blows/ft or more.

For noise walls or retaining walls, at least one boring per wall should be completed at the most likely wall face location. Walls longer than 300 feet should have additional borings spaced every 300 ft to 500 ft. For taller retaining walls (e.g., 30 to 40 ft or more in height), or retaining walls that may be soil nail or tie-back walls, borings should be completed behind the wall face to evaluate overall stability and ground anchor feasibility. The spacing on these borings should be twice the spacing of the borings along the wall face. The depth of borings for noise walls should be a minimum of 20 feet. Borings for retaining walls in fill situations should extend below the ground surface at least twice the wall height. Borings for retaining walls in cut situations should extend below the ground surface at least three times the exposed height of the wall.

For infiltration or detention facilities, at least one boring per site should be obtained to assess feasibility and define groundwater conditions. Boring depths will depend on the nature of the subsurface conditions encountered and the depth of influence of the geotechnical feature. Borings should extend at least 20 feet below the likely base elevation of the facility, or five times the maximum anticipated ponded water depth, whichever is greater. It is desirable to install piezometers and monitor them for at least one year prior to advertisement to assess yearly high and lows for the groundwater.

For landslides or unstable areas, multiple borings will likely be required as well as detailed field mapping of the landslide. As a minimum, at least two borings will be required, and instrumented with an inclinometer and a piezometer. Additional borings may be needed to define failure planes, stratigraphy, and groundwater. Boring depths will vary.

Greater boring spacing than those described above may be feasible provided the geotechnical site reconnaissance and the known site geology indicate that high quality soils are present and that conditions are fairly uniform and predictable within the project limits. If subsurface conditions are observed to be erratic based on the available data and site observations or if higher risk conditions are identified (see below), closer boring spacing may be needed to better define the extent of the specific condition of concern (e.g., soft soil deposits, liquefiable deposits, etc.). Geophysical methods can be used to supplement the borings and reduce the number of borings required.

Risks to be considered that could require a more detailed investigation than what may be considered typical shall include, but not be limited to, the following:

- liquefiable soils,
- very soft soils,
- areas of previous or potential instability (e.g., landslides, rockfall, severe erosion, etc.),
- rockslopes, and
- high groundwater.

The degree of investigation necessary to mitigate these risks will depend on the nature of the risk, the amount of detailed geotechnical information needed to mitigate that risk, and the impact such risks have on the potential project costs. To determine the amount of additional investigation required for these high-risk issues for a GBR level of investigation, the impact of such conditions on the ability of bidders to adequately estimate project costs and project staging/schedule shall be considered.

22.3 Policy – Level of Geotechnical Design and GBR Contents in Consideration of Risk Mitigation

All factual data that are obtained to develop the GBR (e.g., boring logs, geophysical test results, field test results, laboratory test results) shall be included in the GBR. Boring logs should be plotted on a project profile and/or cross-sections of specific project elements. Interpolation between borings to develop stratigraphy should not be done at this stage as borings are likely not spaced close enough to accurately define the stratigraphy. It is likely that the design-builder will obtain additional borings during design that can be used to define the stratigraphy. The GBR may need to provide an interpretive tie between the borings and the site geological interpretation of the soils and rock strata encountered. This interpretation is required to identify potential geological hazards not specifically encountered in the borings, but that are nevertheless likely to be encountered based on the general soil and rock types encountered in the borings, probes, or geophysical surveys. As such, the GBR should provide a summary of the regional and site geology for the project, as well as an evaluation of seismicity at the site.

If there is potential for soil liquefaction at the site, a preliminary assessment of the depth and extent of the liquefiable soils should be identified. A preliminary assessment of the feasibility of potential mitigation schemes may also be required, as well as an assessment of the impact of liquefaction on the proposed project features, depending on the impact to project feasibility. If the liquefaction hazard could affect the decision on whether to widen or replace an existing bridge or similar structure, and if the design assumptions and parameters needed to make that assessment could vary significantly between proposers such that the project scope could vary significantly (e.g., some proposers feel no stabilization is needed, while others feel that stabilization is necessary or the bridge must be replaced rather than widened), a complete liquefaction investigation and mitigation design may need to be included in the RFP.

A characterization of the on-site materials as fill should also be made. A preliminary assessment of feasible cut and fill slopes should also be made to assess right-of-way needs and/or the need for retaining walls. Broad guidance on the feasibility of various wall types should also be provided. For structures, an assessment of the foundation types that are or are not feasible should also be provided.

For ground and storm water treatment, the geotechnical feasibility of proposed treatment strategies (e.g., infiltration ponds, detention facilities, etc.) should be assessed. This geotechnical feasibility includes assessing the effect of ground water and soil type on infiltration, stability of the facility, and the ability to construct the facility.

Any key constructability issues that need attention during the bidding process for constructing cuts and fills, especially construction staging and schedule issues, settlement, and stability concerns, for installing structure foundations, or to install walls (especially cut walls such as soil nail or tieback walls) should be identified.

22.4 Policy – Geotechnical Investigation During RFP Advertisement

Often with design build, specific project elements cannot be reasonably defined at the time the GBR and RFP are produced. To help minimize contingency costs in the bids and limit risk, it may be desirable to perform supplemental geotechnical investigations during the RFP process to augment the GBR. Whether or not supplemental geotechnical investigations should be completed during the RFP process is determined by mutual agreement between the State Geotechnical Engineer and Region/Headquarters management prior to advertisement of the RFP. Should supplemental investigation occur, the short-listed bidders should submit requests for additional information including locations and depths of borings. The State will evaluate the requests and develop an exploration program that eliminates duplication of borings in specific locations, eliminating potential conflicts between bidders, unwanted congestion due to the presence of multiple sets of drilling rigs and multiple crews, and to reduce costs through elimination of duplicated efforts. An example supplementary boring program is provided in **WSDOT GDM Appendix 22-A**.

22.5 Discussion

The amount of investigation required is highly dependent on the uniformity and predictability of the site conditions, the impact those conditions may have on the cost to construct the project, the risk associated with those conditions, and the overall size and complexity of the project. The description of the "typical" investigation program provided above should only be used as a starting point for developing the investigation plan for a design-build project. The high-risk issues identified in "Policy – Field Investigation Requirements" will generally require a more thorough investigation. For example, evaluation of liquefaction and the degree of mitigation required are strongly dependent on the specific soil gradation and layering present. Such details can affect the type of mitigation that is feasible, possibly doubling or even quadrupling the mitigation costs, and could affect the foundation type(s) that are feasible and their associated costs. The nature of any very soft soils present can affect the cost of mitigation required, and affect where fills can be used in lieu of expensive structures. Soft soils can also affect the performance and rideability of pavements, and the degree and cost of mitigation required. Construction staging and schedule impacts, in this case, can vary widely from minimal overexcavation to more expensive soil improvement strategies (to improve settlement, slope stability, or both), to long construction delays to wait out the settlement and/or improve stability. Areas of previous or potential instability can affect the feasibility of a given alignment (i.e., there may not be room available to fit in the mitigation solution needed), or possibly require the use of very expensive structural solutions (e.g., cylinder pile or tieback walls). The cost to stabilize an existing or new rock slope is highly dependent on the geologic structure of the rock mass, requiring the rock mass structure to be well defined to provide an adequate basis for bidding. If the rockslope cannot be stabilized, there must be adequate room to capture the rocks before they reach the transportation facility, also affecting feasibility. The presence of high ground water, in consideration of seasonal variations, can affect the feasibility of infiltration and even detention facilities, and minor differences in soil gradation can cause infiltration facility sizes to vary by an order of magnitude. This issue can affect environmental permitting as well. The presence of groundwater can affect certain types of construction, such as tunneling, pipe jacking, shaft foundations, as well as affect their feasibility.

Regarding cost and risk of cost overruns, enough geotechnical data and analysis must be provided so that the design-builder has a reasonably clear picture of the subsurface conditions and the effect of those conditions have on constructability and the total cost of what is to be constructed. Poorly defined conditions can result in wide swings in the cost of the design solutions needed, resulting in the need for more definition and impact assessment. This is especially critical regarding the high-risk issues described above. Subsurface explorations should not be conducted in locations where the subsurface conditions will have negligible impact on the project design and resulting construction cost.

The same philosophy applies to geotechnical analysis and design. The focus of any geotechnical analysis or design conducted in support of the GBR must be to evaluate feasibility only, and to reduce the potential for bidders to have wide swings in their estimate of project costs. For example, if shafts or piles are proposed as foundations for a bridge, the specific foundation loads will not be known accurately enough during GBR and RFP development to determine foundation depths and sizes. Therefore, detailed analysis of foundation skin friction and end bearing resistance would be of little use. The design-builder would have to redo such calculations during final design anyway. What is of more use is whether or not shaft or pile foundations are feasible to install, considering impacts to adjacent facilities, ability for equipment of sufficient size to access potential pier locations, etc. Enough information must be provided to bidders so that they can determine what foundation types are feasible.

Since the geotechnical investigation at time of bidding is generally inadequate to complete the final design, it would be risky for the State to provide a detailed stratigraphy of the subsurface conditions. In general, interpolation between borings should not be conducted prior to bidding. Geotechnical data at this stage should be presented with a minimum of interpretation. If geological interpretation of the conditions encountered would indicate that geotechnical hazards not specifically encountered in the borings should be anticipated (e.g., potential boulders, liquefiable soil, unstable conditions, earthquake faults, etc.), such hazards should be identified as likely to be encountered at the site. If geological interpretations must be provided to identify the potential for encountering such hazards, the report must be clear that these are interpretations.

Since the GBR will typically be made a part of the RFP, a distinction must be made in the GBR as to what data, interpretations, and recommendations are to be considered the basis for bidding or are otherwise obligatory contractually, and information provided in the GBR that is not considered obligatory (e.g., background information used by WSDOT to develop the project in a way that insures project feasibility, such as information used to size infiltration ponds, settlement time rate information used to establish construction staging criteria or constraints). This could be handled by putting these two types of information in separate sections of the report, and clearly identifying what is obligatory and what is not obligatory. This could also be handled by producing two separate reports, one that is included in the RFP, and one that is referenced and made available to potential bidders as informational only.

Appendix 22-A Example Supplemental Geotechnical Boring Program Provisions

In order to aid the Proposers in partially fulfilling these responsibilities, WSDOT plans to provide an opportunity for each Proposer to obtain additional geotechnical information at WSDOT's expense pursuant to Section 1-02.4(2) below. The Department makes no representation as to whether said Supplemental Boring Program will be sufficient for the Proposer to discharge its responsibilities set forth in the preceding paragraph. Each Proposer must make this determination independently based upon its own independent judgment and experience.

Because the geotechnical information necessary for each Proposer varies with each Proposer's design, it is recognized that the subsurface information provided with the Request for Best and Final Proposal may not provide all the geotechnical information that the Proposer may determine is necessary. Therefore, WSDOT will provide at its own cost additional geotechnical investigation as directed by the Proposers, subject to the limitations as provided herein, to be known as the "Supplemental Boring Program".

The Proposer is responsible for submitting to the Engineer, in writing, a Boring Program detailing the location (by station and offset) and highest bottom elevation of their requested borings by October 19, 2000. Late submittals will not be accepted. Failure to submit such a Boring Program by said date will constitute a conclusive presumption that the Proposer has determined that it does not require any additional geotechnical data to properly design, construct and price the work or that the Proposer intends to obtain such data at its expense. Each Proposer may submit up to three (3) boring locations. WSDOT will make every effort to locate the borings where requested. The borings will be performed at the locations requested, except that proposed boring locations within 20 feet of another will be averaged to one proposed location. If a Proposer's boring is averaged with another Proposer's boring, neither Proposer will be allowed an additional boring. Soon after October 26, 2000, the locations of all borings will be distributed to all Proposers in writing. Whether or not the Proposer's requested borings were located exactly where requested, the requirements of Section 1-02.4(1) will still apply.

The Supplemental Boring Program will be performed by WSDOT in-house staff or an independent, qualified, drilling contractor. The borings will be inspected by a qualified inspector working for WSDOT and boring locations and elevations will be established by survey personnel provided by WSDOT. At the option of the Proposer, the Proposer may have a maximum of one on-site person to witness the drilling, sampling, testing and coring. All such on-site persons shall not interfere with the operation of the drillers and inspector, and shall coordinate transportation to the drilling site with WSDOT.

The WSDOT drill crew or drilling contractor will be prepared to conduct the following sampling and testing procedures in the 2000 Supplemental Boring Program: split-spoon samples and Standard Penetration Tests at five foot intervals and every change in stratum, minimum NQ-size rock cores, minimum ten foot rock cores with RQD; field vane shear tests in soft clays; electronic cone penetrometer testing, conventional laboratory classification testing on disturbed soil samples; conventional laboratory tests on rock samples. The Proposer is responsible for including in its Boring Program submittal: the frequency and depth of field vane tests, the locations of split spoon samples and SPT tests, and the length and diameter of rock cores. Furthermore, the Proposer is responsible for including in its Boring Program submittal the depth of disturbed samples, undisturbed samples, and rock cores that they wish to obtain, and the corresponding tests to be conducted.

The State will perform the test borings in the order of its choice. Mobilization will take place on or about October 26, 2000. The Supplemental Boring Program Report, containing the final boring logs and laboratory test results, will be shared with all Proposers on or about November 27, 2000. Soil and rock samples that are not consumed by testing will be stored for inspection by the Proposers at the WSDOT Materials Laboratory. To examine these samples, refer to Section 1-03.4(2). Furthermore, all of the samples not consumed by testing, including disturbed samples, undisturbed samples, and rock cores, will be turned over to the Design-Builder immediately after the contract is awarded.